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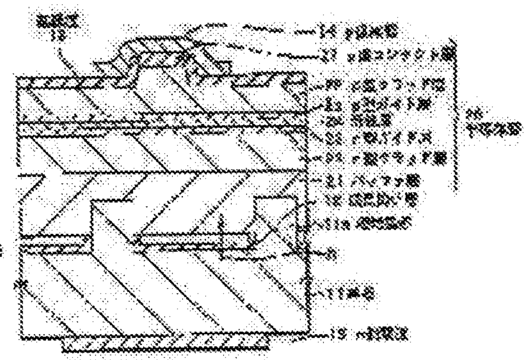
(54) SEMICONDUCTOR LASER, SEMICONDUCTOR DEVICE AND PRODUCTION METHOD THEREFOR

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a semiconductor laser, a semiconductor device and a production method therefor, with which a dislocation density is reduced and the characteristics of the device can be improved.
SOLUTION: A semiconductor layer 20 composed of a nitride III-V compound semiconductor is laminated on a substrate 11 composed of n-type GaN. On the substrate 11, a projecting species crystal part 11a is formed and a growth suppressing layer 12 having an opening is provided corresponding to the species crystal part 11a. The semiconductor layer 20 is grown on the basis of the species crystal part 11a and has the lateral growing area of low dislocation density. When the current injecting area of an active layer 24 is provided corresponding to this lateral growing area, light emission efficiency can be improved. Further, when the growth suppressing layer 12 has an ability for reflecting or absorbing light generated on the semiconductor layer 20, the entrance of light leaked from the side of the substrate 11 or stray light can be prevented and the generation of noise can be suppressed.



CLAIMS

[Claim(s)]
[Claim 1]A semiconductor laser comprising:
A substrate which consists of a nitride system III-V fellows compound, and has a **-like seed crystal section.
A semiconductor layer which consisted of a nitride system group III-V semiconducter, grew on the basis of said seed crystal section, and was laminated by said substrate.
A growth deterrence layer which is provided between said substrate and said semiconductor layer, and has an opening corresponding to said seed crystal section.

[Claim 2]The semiconductor laser according to claim 1 having a gap between said semiconductor layer and said growth deterrence layer.

[Claim 3]The semiconductor laser according to claim 1, wherein said growth deterrence layer has a function which reflects or absorbs light generated in said semiconductor layer.
[Claim 4]The semiconductor laser according to claim 1, wherein said active layer has a current injection region where current is poured in corresponding to said transverse direction growing region including a transverse direction growing region formed by said semiconductor layer's having an active layer, and growing up in the different direction from a laminating direction of said semiconductor layer.
[Claim 5]The semiconductor laser according to claim 4 characterized by said active layer having a current injection region among said transverse direction growing regions corresponding to a field between said seed crystal section and said meeting part including a meeting part formed when said semiconductor layer grew in the different direction from a laminating direction of said semiconductor layer.
[Claim 6]A semiconductor device comprising:
A substrate which consists of a nitride system III-V fellows compound, and has a **-like seed crystal section.
A semiconductor layer which consisted of a nitride system group III-V semiconducter, grew on the basis of said seed crystal section, and was laminated by said substrate.
A growth deterrence layer which is provided between said substrate and said semiconductor layer, and has an opening corresponding to said seed crystal section.

[Claim 7]A manufacturing method of a semiconductor laser characterized by comprising the following.
A process which makes a substrate which consists of a nitride system III-V fellows compound estrange a **-like seed crystal section, and are formed in it.
A process of forming on a substrate a growth deterrence layer which has an opening corresponding to a seed crystal section.
A process into which a semiconductor layer which comes from a nitride system group III-V semiconducter on the basis of a seed crystal section on a substrate is grown up.

[Claim 8]a current injection region where an active layer is grown up at least as a semiconductor layer, and current is poured into an active layer -- alienation of a seed crystal section -- a manufacturing method of the semiconductor laser according to claim 7 forming corresponding to a field.
[Claim 9]alienation [in / for a current injection region where current is poured into an active layer / a seed crystal section and its arrangement direction] -- a manufacturing method of the semiconductor laser according to claim 8 forming corresponding to a field between the centers of a field.
[Claim 10]A manufacturing method of a semiconductor device characterized by comprising the following.
A process which makes a substrate which consists of a nitride system III-V fellows compound estrange a **-like seed crystal section, and are formed in it.
A process of forming on a substrate a growth deterrence layer which has an opening corresponding to a seed crystal section.
A process into which a semiconductor layer which comes from a nitride system group III-V semiconducter on the basis of a seed crystal section on a substrate is grown up.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]

[Field of the Invention]This invention relates to the semiconductor laser provided with the substrate which consists of a nitride system III-V fellows compound, and the semiconductor layer which consists of a nitride system group III-V semiconducter who made it grow up on the basis of this substrate, semiconductor devices, and those manufacturing methods.

[0002]

[Description of the Prior Art]Nitride system groups III-V semiconducter, such as GaN, an AlGaN mix crystal, or a GaInN mix crystal, are the semiconductor materials of direct transition, and they have the feature that forbidden-band width is continuing for 1.9 eV - 6.2 eV. Therefore, these nitride system groups III-V semiconducter, Luminescence from a visible region to an ultraviolet region can be obtained, and it is observed as a material which constitutes semiconductor light emitting elements, such as a semiconductor laser (laser diode;LD) or a light emitting diode (light emitting diode;LED). Since saturation electronic speed and the destructive electric field are large, the nitride system group III-V semiconducter attracts attention also as a material which constitutes an electronic device.

[0003]These semiconductor devices were manufactured by using vapor phase growth and growing up a nitride system group's III-V semiconducter layer conventionally, on the base for growth which consists of sapphire (alpha-aluminum $_2O_3$) or silicon carbide (SiC). However, in sapphire or silicon carbide, and a nitride system group III-V semiconducter, the difference of a stacking fault or a coefficient of thermal expansion was large, and in order to ease distortion in a nitride system group's III-V semiconducter layer, lattice defects, such as a rearrangement, had occurred. Thus, if a lattice defect occurs, a defective part will be the center of nonluminescent recombination or current leakage part which does not emit light even if an electron and an electron hole recombine, and optical or the electrical property of a semiconductor device will be spoiled.

[0004]Then, in recent years, using the substrate which consists of a nitride system III-V fellows compound is examined. The substrate which consists of this nitride system III-V fellows compound is manufactured by dissociating from the base for growth, after making it grow up on the base for growth which consists of sapphire etc. for example. Since the problem mentioned above is solvable if the substrate which consists of this nitride system III-V fellows compound is used, and the thermal conductivity outstanding compared with the substrate of sapphire can be obtained, the heat generated at the time of a drive can be radiated effectively, and there is flume ******. Since an electrode can be provided in the rear face of a substrate if an impurity is added and conductivity is given, area of an element can be made small and there is also an advantage that high density assembly becomes possible.

[0005]

[Problem(s) to be Solved by the Invention]However, since the substrate which consists of a nitride system III-V fellows compound was manufactured by making it grow up on the base for growth which consists of sapphire etc., for example, there was a problem that dislocation density was as high as $1\times10^{8}cm^{-2}$ - a $1\times10^{11}cm^{-2}$ grade. Therefore, dislocation density was able to become high also about the layer of the nitride system group III-V semiconducter who makes it grow up on a substrate, and an element characteristic was not able to be raised.

[0006]This invention was made in view of this problem, and the purpose reduces dislocation density and there is in providing the semiconductor laser which can raise the characteristic of an element, semiconductor devices, and those manufacturing methods.

[0007]

[Means for Solving the Problem]A semiconductor laser of this invention is characterized by comprising:

A substrate which consists of a nitride system III-V fellows compound, and has a **-like seed crystal section.

A semiconductor layer which consisted of a nitride system group III-V semiconducter, grew on the basis of a seed crystal section, and was laminated by substrate.

A growth deterrence layer which is provided between a substrate and a semiconductor layer and has an opening corresponding to a seed crystal section.

[0008]A semiconductor device of this invention is characterized by comprising:

A substrate which consists of a nitride system III-V fellows compound, and has a **-like seed crystal section.

A semiconductor layer which consisted of a nitride system group III-V semiconducter, grew on the basis of a seed crystal section, and was laminated by substrate.

A growth deterrence layer which is provided between a substrate and a semiconductor layer and has an opening corresponding to a seed crystal section.

[0009]A process which a manufacturing method of a semiconductor laser by this invention makes a substrate which consists of a nitride system III-V fellows compound estrange a **-like seed crystal section, and are

formed. A process of forming on a substrate a growth deterrence layer which has an opening corresponding to a seed crystal section, and a process into which a semiconductor layer which comes from a nitride system group III-V semiconducter on the basis of a seed crystal section on a substrate is grown up are included.

[0010]A process which a manufacturing method of a semiconductor device by this invention makes a substrate which consists of a nitride system III-V fellows compound estrange a **-like seed crystal section, and are formed. A process of forming on a substrate a growth deterrence layer which has an opening corresponding to a seed crystal section, and a process into which a semiconductor layer which comes from a nitride system group III-V semiconducter on the basis of a seed crystal section on a substrate is grown up are included.

[0011]In a semiconductor laser and a semiconductor device by this invention, since a semiconductor layer is growing on the basis of a seed crystal section of a substrate, dislocation density of a semiconductor layer is reduced.

[0012]In a manufacturing method of a semiconductor laser by this invention, or a manufacturing method of a semiconductor device, after estranging to a substrate, forming two or more seed crystal sections and forming a growth deterrence layer which has an opening corresponding to this seed crystal section, a semiconductor layer grows on the basis of a seed crystal section. Therefore, a semiconductor layer with low dislocation density is obtained.

[0013]

[Embodiment of the Invention]Hereafter, an embodiment of the invention is described in detail with reference to drawings.

[0014]Drawing 1 expresses the section structure of the semiconductor laser as a semiconductor device concerning the 1 embodiment of this invention. This semiconductor laser is provided with the following.

The substrate 10 which consists of a nitride system III-V fellows compound.

The semiconductor layer 20 which consists of a nitride system group III-V semiconducter laminated at the whole surface side of this substrate 10.

A nitride system III-V fellows compound or the nitride system group III-V semiconducter refers to at least one sort in 3B group element in the short period type periodic table, the compound of the 5B group elements in the short period type periodic table which contains nitrogen at least, or the thing of a compound semiconductor here.

[0015]The thickness (only henceforth thickness) in the laminating direction of the semiconductor layer 20 is 250 micrometers, and the substrate 11 is constituted by n type GaN which added silicon (Si) as a n type impurity, for example. The **-like seed crystal section 11a is formed in the whole surface side of the substrate 11. For example this seed crystal section 11a is extended by band-like (in drawing 1, it extends in the vertical direction to space), is estranged to stripe shape, and is arranged. [two or more] The seed crystal section 11a is formed in the {0001} sides of the substrate 11, and is extended in the direction shown in outside 1 or outside 2, for example.

[0016]

[External Character 1]

$\langle 1\bar{1}00 \rangle$

[External Character 2]

$\langle 11\bar{2}0 \rangle$

[0017]It is preferred that it is within the limits of 1.5 micrometers - 6 micrometers, for example, and if the width of an interface with the buffer layer 21 in the arrangement direction (it is a vertical direction to an extending direction) of the seed crystal section 11a is within the limits of not less than 2 micrometers 5 micrometers or less, it is more preferred. It is because it will be easy to produce fluctuation in the crystal axis of the buffer layer 21 if wide [if width is narrow, at the time of manufacture, the buffer layer 21 will exfoliate easily, and]. It is preferred that it is not less than 9 micrometers, for example, and if the clearance of the seed crystal section 11a is not less than 10 micrometers, it is more preferred. It is because a process margin will become narrow in the case of mask alignment, etc. at the time of manufacture and productivity will fall, if clearance is short. The height of the seed crystal section 11a is 1 micrometer - 3 micrometers. It is because it is difficult to secure a gap between the growth deterrence layer 12 and the semiconductor layer 20 which will be later mentioned if lower than 1 micrometer, and the crystal axis of the semiconductor layer 20 will become difficult to be assembled if higher than 3 micrometers.

[0018]Between the substrate 11 and the semiconductor layer 20, the growth deterrence layer 12 which has an opening corresponding to the seed crystal section 11a is formed. the growth deterrence layer 12 grows up the semiconductor layer 20 on the basis of the seed crystal section 11a of the substrate 11 — alienation of the

seed crystal section 11a -- it is to keep the semiconductor layer 20 from growing from a field. The growth deterrence layer 12 is constituted by dielectric, for example, and specifically, It is constituted by monolayers, such as a silica dioxide (SiO_2), silicon nitride (Si_3N_4), a titanium dioxide (TiO_2), or an aluminum oxide (aluminum$_2O_3$), or cascade screen or more using two of sorts of these.

[0019]the growth suppression layer 12 -- alienation of the seed crystal section 11a -- it is preferred that cover the root portion not only along with a field but along with the seed crystal section 11a, and a gap produces between the semiconductor layer 20 and the growth suppression layer 12. It is to prevent a defect from the semiconductor layer 20 contacting the substrate 11 and occurring, when growing up the semiconductor layer 20 on the basis of the seed crystal section 11a. As for height h of a standup portion in alignment with the seed crystal section 11a of the growth deterrence layer 12, it is preferred that it is not less than 10 nm for example. It is because contact with the semiconductor layer 20 and the growth deterrence layer 12 cannot be effectively prevented in less than 10 nm.

[0020]As for the growth deterrence layer 12, it is preferred to have a function which reflects or absorbs further light generated in the semiconductor layer 20. It is because it can control that the stray light reflected within a package advances from the substrate 11 side when it can control that light generated in the semiconductor layer 20 leaks from the substrate 11 side, and a package etc. are stored and it is used. Such a function is obtained even if it constitutes the growth deterrence layer 12 from material mentioned above.

[0021]The semiconductor layer 20 is growing on the basis of the seed crystal section 11a of the substrate 11, and the buffer layer 21, the n type clad layer 22, the n type guide layer 23, the active layer 24, the p type guide layer 25, the p type clad layer 26, and the p side contact layer 27 are laminated by this order from the substrate 11 side.

[0022]Thickness is 0.04 micrometer and the buffer layer 21 is constituted by n type GaN by which silicon was added as a n type impurity, for example. this buffer layer 21 -- alienation of the seed crystal section 11a -- corresponding to a field, it has the transverse direction growing region grown-up in the different direction from a laminating direction of the semiconductor layer 20 on the basis of a wall surface of the seed crystal section 11a. Specifically, this transverse direction growing region is a field which has a growth ingredient to a vertical direction to a laminating direction of the semiconductor layer 20.

[0023]As this transverse direction growing region was shown in drawing 2, it is hard to spread penetration dislocation M_1 from the seed crystal section 11a, and dislocation density is low. Thereby, dislocation density of a portion corresponding to a transverse direction growing region of below $1 \times 10^{6} cm^{-2}$ is low, for example also about the semiconductor layer 20 from the n type clad layer 22 laminated on the buffer layer 21 to the p side contact layer 27. On the other hand, in a field corresponding to the seed crystal section 11a, penetration dislocation M_1 from the seed crystal section 11a spreads among the buffer layers 21. This buffer layer 21 has the meeting part B formed when the crystals grown-up in the direction of a transverse direction growing region which is mostly different from a laminating direction in the central part met again, and penetration dislocation M_2 generated by meeting exists in the meeting part B. This penetration dislocation M_2 spreads in many cases to the semiconductor layer 20 from the n type clad layer 22 laminated on the buffer layer 21 to the p side contact layer 27.

[0024]Thickness is 1 micrometer and the n type clad layer 22 is constituted by n type AlGaN mix crystal which added silicon as a n type impurity, for example. Thickness is 0.1 micrometer and the n type guide layer 23 is constituted by n type GaN which added silicon as a n type impurity, for example.

[0025]Thickness is 30 nm and the active layer 24 has the multiple quantum well structure which laminated $Ga_xIn_{1-x}N$ (however, 1>=x>=0) mixed crystal layers from which a presentation differs, for example. This active layer 16 has a current injection region where current is poured in, and a current injection region functions as a luminous region.

[0026]Thickness is 0.1 micrometer and the p type guide layer 25 is constituted by p type GaN which added magnesium (Mg) as a p type impurity, for example. Thickness is 0.8 micrometer and the p type clad layer 26 is constituted by p type AlGaN mix crystal which added magnesium as a p type impurity, for example. Thickness is 0.5 micrometer and the p side contact layer 27 is constituted by p type GaN which added magnesium as a p type impurity, for example. A part of p side contact layer 27 and p type clad layer 26 are made into the shape of a thin band (band-like [which was perpendicularly extended to space in drawing 1]), and it constitutes a current stricture part.

[0027]This current stricture part is for restricting a current injection region where current is poured into the active layer 24, and a portion corresponding to a current stricture part serves as a current injection region

among the active layers 24, and it serves as a luminous region. Therefore, in order to prevent degradation of an element characteristic and to raise it, it is preferred that a current injection region (namely, current stricture part) is formed corresponding to a transverse direction growing region where dislocation density is low. However, since penetration dislocation M_2 (refer to drawing 2) exists in the meeting part B of a crystal, it is more desirable if a current injection region is provided corresponding to a field between the seed crystal section 11a and the meeting part B.

[0028]Penetration dislocation M_1 is in a tendency which spreads and spreads only deltaL $_1$ to an arrangement direction from the end C in an interface by the side of the active layer 24 of the seed crystal section 11a as thickness of the semiconductor layer 20 becomes thick. Penetration dislocation M_2 is in a tendency which spreads and spreads only deltaL $_2$ from the meeting part B to an arrangement direction. Therefore, near the seed crystal section 11a and the meeting part B, there is a possibility that penetration dislocation M_1 and M_2 may spread. Therefore, in order to make lower a possibility that penetration dislocation M_1 and M_2 will enter a luminous region and to acquire sufficient element characteristic. It is preferred to provide a current injection region corresponding to inside of a field which more than deltaL$_1$ separated from the end C in an interface by the side of the active layer 24 of the seed crystal section 11a to an arrangement direction, and more than deltaL$_2$ separated from the meeting part B to an arrangement direction.

[0029]Incidentally, penetration dislocation M_1, spread deltaL$_1$ of M_2, and deltaL$_2$ are in thickness and proportionality of the semiconductor layer 20. for example, alienation of the seed crystal section 11a -- the sum total of thickness of the buffer layer 21 in a field, the n type clad layer 22, the n type guide layer 23, the active layer 24, the p type guide layer 25, the p type clad layer 26, and the p side contact layer 27 being made into t_1, and, When thickness of a portion corresponding to the buffer layer 21 is made into t_2, among the seed crystal sections 11a spread deltaL$_1$ of penetration dislocation M_1, It approximates with deltaL$_1$ = (t_1-t_2) / 20, and spread deltaL$_2$ of penetration dislocation M_2 is set to deltaL$_2$=t_1/20.

[0030]If distance in an arrangement direction from the end C in an interface by the side of the active layer 24 of the seed crystal section 11a and distance in an arrangement direction from the meeting part B form an injection region corresponding to inside of a field which is both 0.93 micrometers or more, Since an element characteristic can be raised further, it is desirable. Since it is thought that diffusion length of a minority carrier under GaN crystal is comparable also about diffusion length under crystal of a nitride system group III-V semiconducter who is 0.93 micrometer and uses here, It is because dislocation density can be made low also about a diffusion region which a minority carrier diffuses from a current injection region. If a luminous region is provided in a field which was separated from the seed crystal section 11a more than deltaL$_1$+0.93 (micrometer) to an arrangement direction, and was separated from the meeting part B more than deltaL$_2$+0.93 (micrometer) to an arrangement direction, and also since dislocation density in a diffusion region can be made low, it is desirable.

[0031]On the semiconductor layer 20, the insulator layer 13 which consists of silica dioxides (SiO_2), for example is formed. Corresponding to the p side contact layer 27, an opening is provided in this insulator layer 13, and the p lateral electrode 14 is formed on the p side contact layer 27. The p lateral electrode 14 has the structure where palladium (Pd), platinum (Pt), and gold (Au) were laminated one by one, for example, and is electrically connected with the p side contact layer 27. on the other hand -- the substrate 11 -- on the other hand, the n lateral electrode 15 is formed in a side, i.e., an opposite hand of the semiconductor layer 20. The n lateral electrode 15 has the structure which laminated titanium (Ti) and aluminum (aluminum) one by one, for example, and was alloyed by heat treatment, and is electrically connected with the substrate 11.

[0032]In this semiconductor laser, the side of a couple which counters, for example in the length direction of the p side contact layer 27 is a resonator edge face, and a reflector film of a couple which is not illustrated to a resonator edge face of this couple is formed, respectively. A reflector film of these couples is adjusted, respectively so that one side may serve as low reflectance and another side may serve as high reflectance. Thereby, light generated in the active layer 24 goes back and forth, is amplified, and emits between reflector films of a couple as a laser beam from a reflector film by the side of low reflectance.

[0033]This semiconductor laser can be manufactured as follows, for example.

[0034]First, as shown in drawing 3 (A), the substrate 11 which consists of 250-micrometer-thick n type GaN is prepared. Although not illustrated, this substrate 11 can be formed by separating from a base for growth, after making it grow up with hydride vapor phase growth or halide vapor phase growth on a base for growth which consists of sapphire etc. for example. Incidentally, hydride vapor phase growth is vapor phase growth which a

hydride (hydride) contributes to a reaction or transportation of material gas, and halide vapor phase growth is vapor phase growth which halide (halogenide) contributes to a reaction or transportation of material gas.
[0035]Subsequently, on the substrate 11 (for example, {0001} sides) by the CVD (Chemical VaporDeposition) method. The mask layer 31 which consists of 0.3 micrometer - 1 micrometer-thick silicon nitride (Si_3N_4) or a silica dioxide (SiO_2) is formed. This mask layer 31 is good also as a laminated structure of a silicon nitride film and a silica dioxide film, for example.
[0036]Then, as shown in drawing 3 (B), a pattern of two or more stripe shape extended in the direction of outside 1 which formed the 2 micrometers - 5 micrometers-thick photoresist film 32, for example, was mentioned above, or outside 2 is formed on the mask layer 31. This photoresist film 32 and mask layer 31 are for etching the substrate 11 selectively and forming the seed crystal section 11a. After performing pattern formation of the photoresist film 32, as shown in drawing 3 (C), wet etching is performed by using the photoresist film 32 as a mask, for example, the mask layer 31 is removed selectively. The photoresist film 32 is removed after it.
[0037]After removing the photoresist film 32, as shown in drawing 3 (D). For example, by a reactive-ion-etching (ReactiveIon Etching:RIE) method which used gaseous chlorine (Cl_2) for etching gas, the substrate 11 is selectively removed using the mask layer 31. Thereby, the substrate 11 is made to estrange the **-like seed crystal section 11a, and more than one are formed in it.
[0038]After forming the seed crystal section 11a, as shown in drawing 4 (A), the growth deterrence layer 12 is formed with a CVD method on the substrate 11. After forming the growth deterrence layer 12, as shown in drawing 4 (B), the photoresist film 33 is applied on the substrate 11. the photoresist film 33 was exposed after it and it was shown in drawing 4 (C) -- as -- alienation of the seed crystal section 11a -- it leaves a portion corresponding to a field and the photoresist film 33 is removed selectively. Thickness of the photoresist film 33 is controlled by adjusting light volume or exposure time in that case, the surface of the growth deterrence layer 12 corresponding to the seed crystal section 11a is exposed -- and alienation of the seed crystal section 11a -- it is made for the photoresist film 33 to remain by thickness of a grade which does not expose the surface of the growth deterrence layer 12 corresponding to a field, for example, thickness below 1 micrometer
[0039]After removing the photoresist film 33 selectively, as shown in drawing 5 (A), perform wet etching by using the photoresist film 33 as a mask, for example, the growth deterrence layer 12 is removed selectively, and the mask layer 31 is removed. Thereby, the growth deterrence layer 12 is made to correspond to the seed crystal section 11a, and an opening is formed. When forming an opening, as a column of composition also explained, it is preferred that the growth deterrence layer 12 leaves a wrap standup portion for a root along with the seed crystal section 11a. As for thickness of the photoresist film 33, since the photoresist film 33 is also removed in part and thickness becomes thin in this etching, it is preferred to consider it as sufficient thickness including a part to be etched. The photoresist film 33 is removed after it.
[0040]After removing the photoresist film 33, as shown in drawing 5 (B), the buffer layer 21 which consists of n type GaN on the basis of the seed crystal section 11a by the MOCVD (Metal Organic Chemical Vapor Deposition) method is grown up. At this time, crystal growth of the buffer layer 21 is carried out from the upper surface and a wall surface of the seed crystal section 11a, and it grows also in the vertical direction to a laminating direction. If fixed time lapse is carried out, the crystals grown-up in the direction which is different from a laminating direction from a wall surface will meet, and a grown surface will become flat substantially.
[0041]By this, although penetration dislocation M_1 (refer to drawing 2) spreads in a field corresponding to the seed crystal section 11a among the buffer layers 21. Since penetration dislocation M_1 from the seed crystal section 11a is crooked in a transverse direction in a portion corresponding to the other transverse direction growing region, it is hardly spread, but penetration dislocation density of the buffer layer 21 is reduced.
[0042]When growing up the buffer layer 21, it is preferred to make a growth rate into 6 or less micrometer/h. If it is made to grow up more quickly than 6 micrometer/h, fluctuation will become large at a crystal axis of the buffer layer 21, and. It is because fault that do not take a long time for the crystals grown-up in the different direction from a laminating direction on the basis of the seed crystal section 11a to carry out meeting said, and for a grown surface to become flat, or a flat grown surface is not acquired arises. If a growth rate is made into 4 or less micrometer/h, it is more desirable, and it is still more desirable if it is considered as 2 or more micrometer/h. It is because there is a possibility that the surface may be ruined when smaller than 2 micrometer/h although fluctuation of a crystal axis decreases more and a good crystal is obtained if it carries out inh and 4micrometers /or less.
[0043]Here, the growth deterrence layer 12 covers a root portion of the seed crystal section 11a, and since it has a standup portion in alignment with the seed crystal section 11a, fluctuation is prevented from the buffer

layer 21 contacting the growth deterrence layer 12, and a defect occurring or arising in a crystal axis in a transverse direction growing region. When it rises in the growth deterrence layer 12 and a portion is not provided, the crystals grown-up in the different direction from a laminating direction do not meet, but there is also a possibility that a flat field may not be acquired substantially. Although growth from the seed crystal section 11a may advance to the growth deterrence layer 12 side a little not rather than a vertical direction but rather than it to a laminating direction, contact with the buffer layer 21 and the growth deterrence layer 12 is effectively prevented by height h of a standup portion of the growth deterrence layer 12 being not less than 10 nm.

[0044]After growing up the buffer layer 21, on the buffer layer 21, for example by the MOCVD method. The n type clad layer 22 which consists of a n type AlGaN mix crystal, the n type guide layer 23 which consists of n type GaN, the active layer 24 which consists of a undope-GaInN mix crystal which does not add an impurity, the p type guide layer 25 which consists of p type GaN, the p type clad layer 26 which consists of a p type AlGaN mix crystal. And the p side contact layer 27 which consists of p type GaN is grown up one by one.

[0045]When performing MOCVD, as material gas of gallium For example, trimethylgallium (CH_3) ($_3$ Ga), As material gas of aluminum, for example, trimethylaluminum (CH_3) ($_3$aluminum), As material gas of indium, ammonia (NH_3) is used as material gas of trimethylindium (CH_3) ($_3$ In) and nitrogen, respectively. As material gas of magnesium, for example, screw = magnesium cyclopentadienyl (C_5H_5) ($_2$Mg) is used, using a mono silane (SiH_4) as material gas of silicon.

[0046]After growing up the p side contact layer 27, as shown in drawing 6, a mask which is not illustrated on the p side contact layer 27 is formed, and a part of p side contact layer 27 and p type clad layer 26 are selectively etched using this mask. Thereby, the upper part and the p side contact layer 27 of the p type clad layer 26 are made into the shape of a thin band, and a current stricture part is formed.

[0047]that time -- a current stricture part -- alienation of the seed crystal section 11a -- it is preferred to provide corresponding to a field and to form a current injection region of the active layer 24 corresponding to the field. Since penetration dislocation M_2 (refer to drawing 2) exists in the meeting part B located in the central part in an arrangement direction of the seed crystal section 11a, a current stricture part -- the seed crystal section 11a and its alienation -- it is more desirable, if it provides corresponding to a field between centers in an arrangement direction of a field and a current injection region of the active layer 24 is formed in the field.

[0048]As mentioned above, only deltaL_1 is separated from the end C in an interface by the side of the active layer 24 of the seed crystal section 11a, and alienation of the seed crystal section 11a -- it is more desirable if a current injection region of the current stricture part 24, i.e., an active layer, is provided in a field which only deltaL_2 separated from a center in an arrangement direction of a field. alienation of the end C of the seed crystal section 11a, and the seed crystal section 11a -- from a center in an arrangement direction of a field. It is desirable if a current stricture part is formed in a field distant 0.93 micrometers or more, respectively, separating from the end C of the seed crystal section 11a more than deltaL_1+0.93 (micrometer) -- and alienation of the seed crystal section 11a -- it is still more desirable if it is made to form in a field distant from a center in an arrangement direction of a field more than deltaL_2+0.93 (micrometer).

[0049]After forming a current stricture part, on the p type clad layer 26 and the p side contact layer 27, the insulator layer 13 which consists of silica dioxides, for example with vacuum deposition is formed, an opening is provided corresponding to the p side contact layer 27, and the p side contact layer 27 is exposed on the surface. after it and the substrate 11 -- on the other hand, sequent deposition of titanium and the aluminum is carried out to a side, they are alloyed to it, and the n lateral electrode 15 is formed in it. Sequent deposition of palladium, platinum, and the gold is carried out to the surface of the p side contact layer 27, and its neighborhood, for example, and the p lateral electrode 14 is formed in them. After forming the n type electrode 15 and the p lateral electrode 14, respectively, the substrate 11 is prepared in a predetermined size and a reflector film which is not illustrated to a resonator edge face of a couple which counters in the length direction of the p side contact layer 27 is formed. Thereby, a semiconductor laser shown in drawing 1 is completed.

[0050]This semiconductor laser acts as follows.

[0051]In this semiconductor laser, if predetermined voltage is impressed between the p lateral electrode 14 and the n lateral electrode 15, current will be poured into the active layer 24 and luminescence will take place by electronic-electron hole recombination. It is reflected by reflector film which is not illustrated, and this light goes and comes back to the meantime, produces laser oscillation, and is ejected outside as a laser beam. Here, since the semiconductor layer 20 grows on the basis of the seed crystal section 11a of the substrate 11, dislocation density of the semiconductor layer 20 is low. If a current injection region of the active layer 24 is especially

provided corresponding to a transverse direction growing region, dislocation density of a current injection region will become lower. Therefore, degradation of an element does not take place easily and a life is extended.
[0052]If it is constituted so that it may have a function for which the growth deterrence layer 12 reflects or absorbs light generated in the semiconductor layer 20 (mainly active layer 24), leakage of light by the side of the substrate 11 will be prevented by the growth deterrence layer 12. In storing and using a semiconductor laser for a package etc., in a package, a part of ejected laser beam is reflected, and it becomes the stray light, and returns to a semiconductor laser, but the stray light which advances from the substrate 11 side by the growth deterrence layer 12 is reduced. Therefore, generating of a noise is controlled and the characteristics, such as an output change, are improved. Therefore, a drive stabilized also about a semiconductor laser of low-power output is secured.
[0053]Thus, according to this embodiment, form the **-like seed crystal section 11a in the substrate 11, and. Since the growth deterrence layer 12 which has an opening corresponding to the seed crystal section 11a is formed and it was made to grow up the semiconductor layer 20 on the basis of the seed crystal section 11a, dislocation density of the semiconductor layer 20 can be reduced and crystallinity can be raised. Therefore, degradation by impression of voltage does not take place easily, and a life of a semiconductor laser can be made to extend. A rate of nonluminescent recombination resulting from penetration dislocation etc. can be made small, and luminous efficiency can be raised.
[0054]Since a wrap standup portion is provided for a root in the growth deterrence layer 12 along with the seed crystal section 11a and a gap was especially established in it between the growth deterrence layer 12 and the buffer layer 21, When growing up the buffer layer 21 on the basis of the seed crystal section 11a, the buffer layer 21 and the growth deterrence layer 12 can be prevented from contacting. Therefore, density of penetration dislocation in the semiconductor layer 20 can be made low, and fluctuation of a crystal axis can be reduced.
[0055]If it constitutes so that it may have a function for which the growth deterrence layer 12 reflects or absorbs light generated in the semiconductor layer 20, light can be prevented from leaking from the substrate 11 side, and the stray light can be prevented from advancing from the substrate 11 side. Therefore, generating of a noise can be prevented and the characteristics, such as an output change, can be improved. Therefore, a drive stabilized also about a semiconductor laser of low-power output is securable.
[0056]If a current injection region of the active layer 24 is provided corresponding to a transverse direction growing region, luminous efficiency can be raised more, and if a current injection region is provided corresponding to a field between the seed crystal section 11a and the meeting part B, luminous efficiency can be raised further. In addition, if a current injection region is provided corresponding to inside of a field which more than deltaL_1 separated from the seed crystal section 11a, and more than deltaL_2 separated from the meeting part B, Or a higher effect can be acquired if a current injection region is provided from the seed crystal section 11a and the meeting part B corresponding to inside of a field distant from 0.93 micrometers or more, respectively.
[0057]As mentioned above, although an embodiment was mentioned and this invention was explained, this invention is not limited to the above-mentioned embodiment, and is variously deformable. For example, although the above-mentioned embodiment explains a case where it has two or more band-like seed crystal sections 11a, depending on a size of an element, it may have only one eventually. The shape of a lattice or island shape may be sufficient as shape of a seed crystal section.
[0058]Although it may be made to provide in other crystal faces although the seed crystal section 11a was formed in {0001} sides of the substrate 11, and the seed crystal section 11a is also made to extend in the direction shown in outside 1 or outside 2 and was formed in the above-mentioned embodiment, it is made to extend in other directions and may be made to form.
[0059]Although the above-mentioned embodiment explained a case where the substrate 11 formed by making it grow up on a base for growth which consists of sapphire etc. was used, this invention is applicable to a case where a substrate produced by other methods is used, similarly.
[0060]In addition, in the above-mentioned embodiment, after removing the mask layer 31, the buffer layer 21 was formed, but it may be made to form the buffer layer 21, without removing the mask layer 31 on the seed crystal section 11a. Thereby, penetration dislocation M_1 is intercepted by the mask layer 31, and propagation of penetration dislocation M_1 from the seed crystal section 11a is prevented. Therefore, the semiconductor layer 20 which a crystal defect hardly exists in the buffer layer 21 except for penetration dislocation M_2 resulting from a meeting, but has the outstanding crystallinity can be obtained. However, since a possibility of mixing into the buffer layer 21 as an impurity, and degrading the characteristic of a semiconductor laser also has a component of the mask layer 31 when growing up the buffer layer 21, it is preferred to choose a proper manufacturing method according to the purpose of use etc.

[0061]Although the above-mentioned embodiment gave and explained an example concretely about composition of a semiconductor laser, this invention is applicable to a semiconductor laser which has other structures similarly again. For example, the n side contact layer 41 which replaces with the buffer layer 21, for example, consists of n type GaN is formed, and it may be made to form the n lateral electrode 15 in the same side as the p lateral electrode 14 to the substrate 11, as shown in drawing 7. In this case, n type GaN may constitute the substrate 11 and it may be made for GaN which does not add an impurity to constitute it.
[0062]It is not necessary to have the n type guide layer 23 and the p type guide layer 25, and, for example, may have a deterioration prevention layer between the active layer 24 and the p type guide layer 25. Although a ridge waveguide type semiconductor laser which combined a profit waveguide type and a refractive-index waveguide type was mentioned as an example and the above-mentioned embodiment explained it, it is applicable to a profit waveguide type semiconductor laser and a refractive-index waveguide type semiconductor laser similarly.
[0063]In addition, although it was made to grow up the semiconductor layer 20 by the MOCVD method in the above-mentioned embodiment, again, MBE (Molecular Beam Epitaxy; molecular beam epitaxy) -- it may be made to form with other vapor phase growth, such as law, hydride vapor phase growth, or halide vapor phase growth
[0064]Although a semiconductor laser was mentioned as an example and the above-mentioned embodiment explained it as a semiconductor device, this invention is applicable to other semiconductor devices, such as a light emitting diode or a field effect transistor, again.
[0065]
[Effect of the Invention]As explained above, according to a semiconductor laser according to any one of claims 1 to 5 or the semiconductor device according to claim 6, have the **-like seed crystal section 11a, and. Since it has a growth deterrence layer which has an opening corresponding to a seed crystal section and was made to grow up a semiconductor layer on the basis of a seed crystal section, the dislocation density of a semiconductor layer can be reduced and crystallinity can be raised. Therefore, the effect that the characteristic of an element can be raised is done so.
[0066]Since it was made to have a gap between a growth deterrence layer and a semiconductor layer especially according to the semiconductor laser according to claim 2, when a semiconductor layer grows, a growth deterrence layer is contacted, and a rearrangement etc. can be prevented from occurring. Therefore, density of penetration dislocation can be made lower and the effect that fluctuation of a crystal axis can be reduced is done so.
[0067]Since it was made to have a function for which a growth deterrence layer reflected or absorbs the light generated in the semiconductor layer according to the semiconductor laser according to claim 3, light can be prevented from leaking from the substrate side, and the stray light can be prevented from advancing from the substrate side. Therefore, generating of a noise can be prevented and the characteristics, such as an output change, can be improved. Therefore, the effect that the drive stabilized also about the semiconductor laser of low-power output is securable is done so.
[0068]Since the current injection region of the active layer was provided corresponding to the transverse direction growing region according to the semiconductor laser according to claim 4 or 5, Since the current injection region was provided corresponding to the field between a seed crystal section and a meeting part, the effect that luminous efficiency can be raised more is done so.
[0069]In addition, according to the manufacturing method of the semiconductor laser according to any one of claims 7 to 9, or the manufacturing method of the semiconductor device according to claim 10. Since it was made to grow up a semiconductor layer on the basis of a seed crystal section after forming the **-like seed crystal section in the substrate and forming the growth deterrence layer which has an opening corresponding to a seed crystal section, The effect that the semiconductor layer which has high crystallinity easily can be manufactured, and the semiconductor laser and semiconductor device of this invention can be manufactured easily is done so.

[Translation done.]

3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]It is a sectional view showing the composition of the semiconductor laser which is a semiconductor device concerning the 1 embodiment of this invention.
[Drawing 2]It is a mimetic diagram showing the generation state of the penetration dislocation in the buffer layer of the semiconductor laser shown in drawing 1.
[Drawing 3]It is a sectional view showing the manufacturing process of the semiconductor laser shown in drawing 1.
[Drawing 4]It is a sectional view showing the manufacturing process following drawing 3.
[Drawing 5]It is a sectional view showing the manufacturing process following drawing 4.
[Drawing 6]It is a sectional view showing the manufacturing process following drawing 5.
[Drawing 7]It is a sectional view showing the modification of the semiconductor laser shown in drawing 1.
[Description of Notations]
11 [--- Insulator layer,] --- A substrate, 11a --- A seed crystal section, 12 --- A growth deterrence layer, 13 14 [--- Buffer layer,] --- p lateral electrode, 15 --- n lateral electrode, 20 --- A semiconductor layer, 21 22 [--- A p type guide layer, 26 / --- A p type clad layer, 27 / --- p side contact layer, 41 / --- n side contact layer, B / --- A meeting part, C / --- An end, M_1, M_2 / --- Penetration dislocation] --- A n type clad layer, 23 --- A n type guide layer, 24 --- An active layer, 25

[Translation done.]

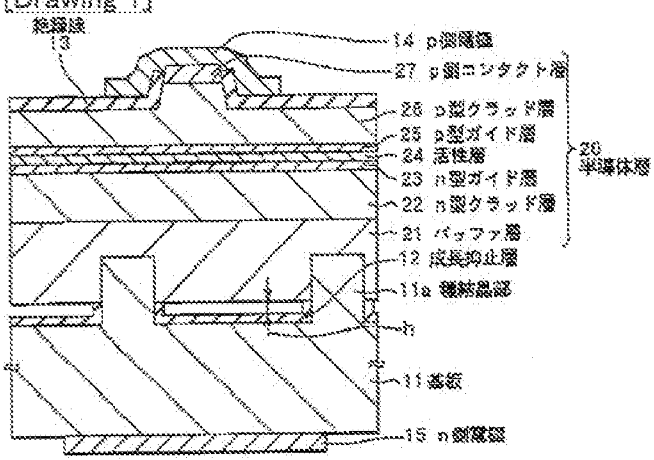
* NOTICES *

JPO and INPIT are not responsible for any
damages caused by the use of this translation.

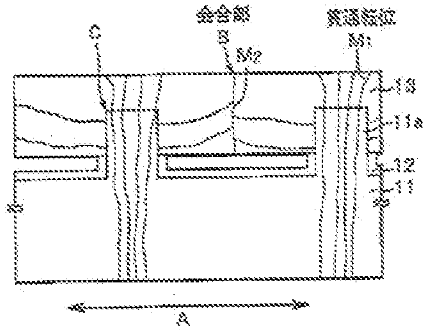
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

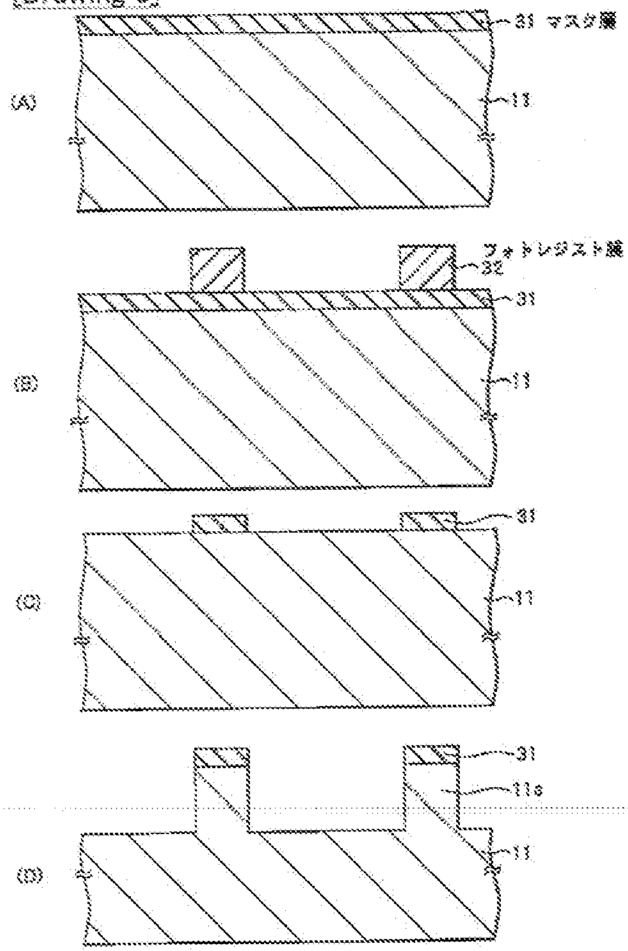
[Drawing 1]



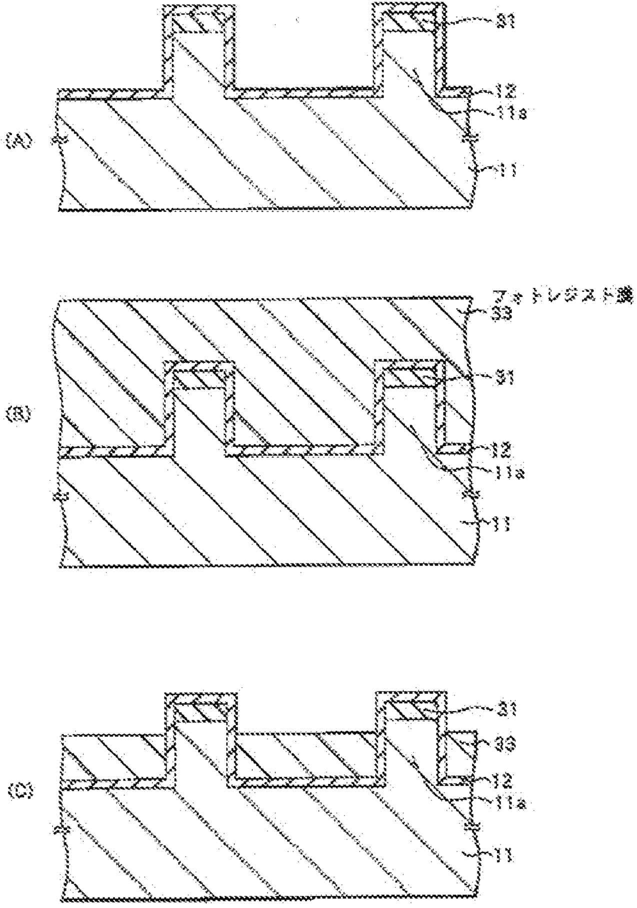
[Drawing 2]



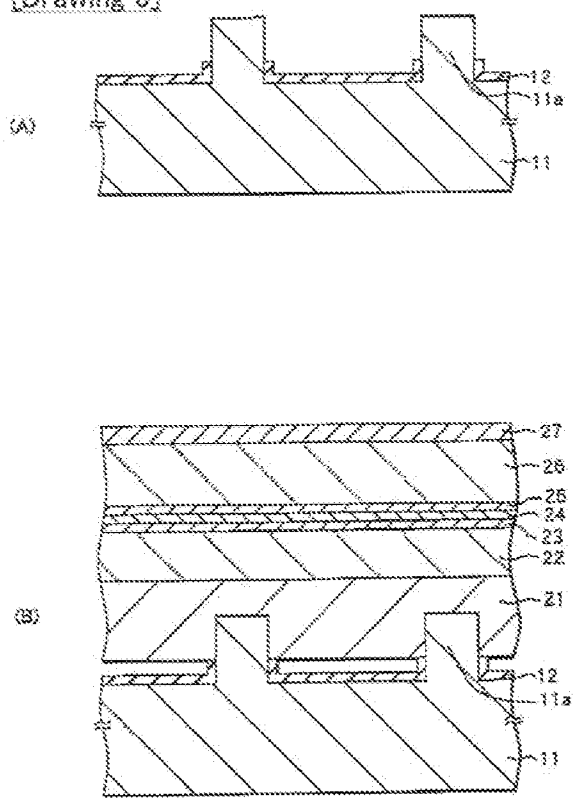
[Drawing 3]



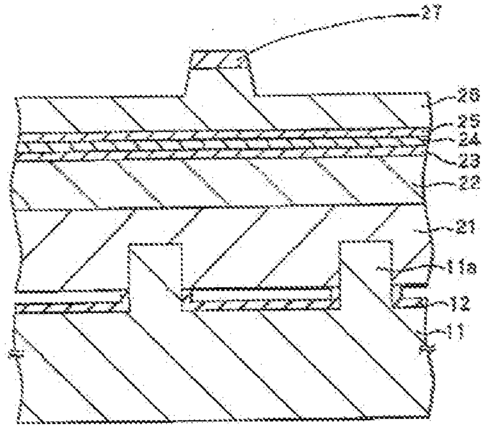
[Drawing 4]



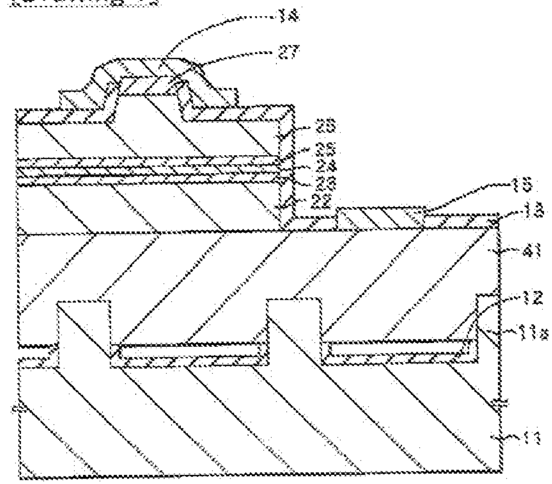
[Drawing 5]



[Drawing 6]



[Drawing 7]



[Translation done.]